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LOSSES FROM QUALITY DETERIORATION AND SHRINKAGE OF CORN RESEALED ON IOWA FARMS

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CONTENTS

	Page
Summary	1
Introduction	2
Farm reseal program	3
Population and sample	4
Method of obtaining information	6
Bushels stored and storage period	7
Quality deterioration and shrinkage from moisture loss	8
Reseal loan costs classified by ownership, type of corn stored, and original price support program	10
Relation of costs of quality deterioration and shrinkage per bushel year of storage to management index, bushels stored, and length of storage	11
Reseal loans for shelled corn	12
Reseal loans for ear corn	13
Appendix A--Management index	14
Appendix B--Statistical analysis	17

List of Tables

Table number	Title	Page
1	Farm reseal loans of 1952 corn in 10 sample counties in Iowa according to type of original price support program	5
2	Sample size and classification of farms storing 1952 loan corn in 1954, by county	6
3	Total and average quantity stored and length of storage of 1952 corn reseal loans for 10 sample counties in Iowa	7
4	Total and average storage volume, storage period, and bushel years of storage of 1952 corn reseal loans, by classification	8
5	Average shrinkage from moisture loss and average quality deterioration of 1952 corn stored on Iowa farms, during reseal period by county	9
6	Weighted average costs of shrinkage and quality deterioration per bushel and per bushel year of farm-stored corn, by county	10
7	Total costs of shrinkage and quality deterioration during reseal period of farm-stored corn, by classification	11
8	Average cost of shrinkage and quality deterioration per bushel and per bushel year of farm-stored corn, by classification	12
9	Average management practices score and total management index of resealed corn on sample Iowa farms, by county	15
10	Management index of farm-stored corn, by classification	16

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LOSSES FROM QUALITY DETERIORATION AND SHRINKAGE FOR CORN RESEALED ON IOWA FARMS

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SUMMARY

A loss of 1.5 cents a bushel in market value[1] of corn stored in farm bins under a reseal program was attributed to deterioration in quality and shrinkage from moisture loss during a period of about 20 months. The extent of the loss in value from these causes during the time the corn was stored under a governmental extended-loan program was determined in a study of Iowa farms resealing corn from the 1952 crop. The storage period commenced in the late fall of 1953 when the corn was resealed and extended until all corn was removed from the storage bins.

On 171 farms making up the sample for this study, a total of 284,080 bushels of resealed corn was stored for an average period of 19.6 months. The average quantity resealed was 1,661 bushels per farm. Seventy-eight farms had an average of 1,388 bushels resealed as ear corn for an average of 20.1 months. The 93 farms resealing shelled corn stored an average of 1,890 bushels for an average period of 19.2 months.

Loss in market value owing to quality deterioration and shrinkage averaged slightly less than one cent a bushel (0.92 cent) for each year of storage on the sample farms. Of this loss in value, 83 percent was attributed to shrinkage from moisture loss and 17 percent to quality deterioration.

Losses due to physical changes were substantially higher in ear corn storage than in shelled corn storage. The total loss in value of corn stored as ear corn averaged one and one-half cents (1.49 cents) a bushel a year. Of this amount, 1.26 cents was due to shrinkage from moisture change and 0.23 cents was due to quality deterioration. For shelled corn storage, the total loss in market value was about one-half cent (0.55 cent) a bushel a year. Shrinkage from moisture change accounted for 0.43 cent of the total loss and quality deterioration for 0.12 cent.

Loss from these causes in market value for resealed corn stored by owner-operators was lower (0.83 cent per bushel per year) than for corn stored by either landlords or tenants. It amounted to 1.04 cents and 1.24 cents, respectively, for the latter 2 groups.

Nineteen of the 171 reseal loans were to landlords, 26 to tenants and 126 to owner-operators. The average size of landlord reseal loans was 2,294 bushels, compared with 1,580 for tenants and 1,582 for owner-operators. The average length of storage was almost identical for all 3 groups.

Price support programs for corn are carried out by loans or by purchase agreements in which the Government agrees to buy eligible corn at a price corresponding with the prevailing loan rate. For corn originally placed under the reseal loan, the loss from

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[1] A market value of $1.50 a bushel was assumed to compute losses in this study. This value corresponds with the average corn loan rate for Iowa for the 1951-52 crop. The reader should consider the relation between current market value of corn and $1.50 in comparing current costs with those reported in this bulletin.

deterioration and shrinkage was 1.06 cents per bushel year. In the case of former purchase agreement corn, no significant change in market value occurred from these causes during the time the corn was resealed in farm bins. One hundred forty-eight of the loans represented corn originally under loan and 23 originally under purchase agreement. Between the 2 groups, there was little difference in either the average size of reseal loans or the average length of storage.

A storage management index was prepared for each reseal loan as an experiment in quantitative analysis of storage management practices adopted by various groups. Five types of information were used to score management practices: method of preparing and filling the bin, use of residual insecticides, inspections made, rodent control, and fumigation. The index averaged 17.9 points for the 171 farms but varied from zero to 54 among the individual farms. The higher scores are presumed to represent closer managerial supervision of storage bins. The index was about twice as high (22.5 points) for shelled corn storage as for ear corn storage (12.3 points). The average was 21.2 points for landlords, 17.1 for tenants, and 17.5 for owner-operators. The index averaged slightly less (17.4 points) for the reseal corn originally extended price support through loans than for corn originally price supported through purchase agreement (20.4).

In general, the loss in market value from deterioration and shrinkage per bushel year of storage decreased as the storage management index score improved, and increased with increases in the number of bushels stored and the number of months the corn was stored. In the case of all sample reseal loans, the cost per bushel year of storage

(a) decreased by one-hundredth of a cent with each increase of 5 points in the management index;

(b) increased about one-tenth of a cent with each month's increase in the length of storage; and

(c) increased by one-hundredth of a cent with each 83-bushel increase in the quantity stored.

Where corn was stored as shelled corn, findings similar to those for all reseal loans were observed. In the case of ear corn storage, however, the relationships between the per unit loss in market value and the contributing factors were substantially different from those for shelled corn storage and for all reseal loans taken together. The regression equations were statistically non-significant in explaining variations in loss in market value of reseal corn stored in the ear. It is recommended that further research be made to develop a more precise measure of storage management for ear corn storage.

INTRODUCTION

This report grew out of a need on the part of corn producers and others concerned with farm storage problems to have more exact knowledge as to the extent of loss in market value due to shrinkage and deterioration in quality of corn stored over an extended period. Also, the Government is directly interested in the degree of such loss because of the large supplies it has acquired under the price support program. The present report sets forth the results of research performed by the Agricultural Marketing Service on this problem.

Until recently, only limited data have been available on the extent of shrinkage and quality deterioration for corn during long storage periods, as related to changes in weights and grades. Usually, we have fed or otherwise utilized most of our corn during the year following its harvest and have carried over only small quantities from one year to another. In recent years, however, stocks of corn have accumulated and have often been held at one location for several years.

Most large stocks of corn are held by Commodity Credit Corporation under provisions of the price support program, and records on receipts and outshipments at various storage facilities are maintained by the Government. Records of comparable data are available on the physical storage of corn in elevators, at Government collection points (bin sites), and on farms. The U. S. Department of Agriculture contracted with Iowa Agricultural Experiment Station, Ames, Iowa, to utilize such data (a) to determine the loss of market value due to shrinkage and quality deterioration of CCC corn stored on farms for an extended period, and (b) to compare farm loss with loss of market value of CCC corn stored at bin sites and in country elevators.[2]

Because Commodity Credit Corporation takes title to corn stored at bin sites and country elevators only after it has been in farm storage (under price support loan or purchase agreement) for a year, comparable farm storage refers to cases where loans have been extended and the corn has been resealed on farms for a period beyond the first storage year. Although sizable quantities of corn produced in the years 1948, 1949, and 1950 were resealed on farms, complete records on this corn were not available at the time the study began. However, records were obtained for corn of the 1952 crop which had been resealed in farm bins.

FARM RESEAL PROGRAM

A farmer having corn stored on the farm who participates in a corn price support program either (a) obtains a loan on his grain following the harvest of the crop and stores the grain on his farm in a bin which is sealed by a county Agricultural Stabilization and Conservation official to prevent unauthorized withdrawal of the corn, or (b) enters into a purchase agreement with the Government in which CCC agrees to buy (within a specified period of time) a stated quantity of eligible corn at a price which corresponds with the prevailing loan rate. If, at the date the original transactions mature, there is insufficient storage space to store the quantities of a commodity under loan and purchase agreement to be delivered to CCC, and if climatic conditions are such that the commodity may be stored safely for another year, the Government may announce a "reseal" program. This program is designed to facilitate the handling of grain during a period when large grain movements from farms could be expected as price support loan collateral is physically delivered to the CCC in competition with labor and facilities required for the harvesting, transporting and storing of new-crop grain. It aims at holding in farm storage that grain which may ultimately be used on the farms.

Farmers who have corn under price support at the maturity date of the original loan may reseal grain on their farms for an additional year in lieu of delivering it to CCC or of repaying the loan. By doing so, they retain title to the corn, and may repay the loan and use or market the corn the same as under the original loan. They receive a storage payment[3] for each additional year's storage under the reseal program.

If the corn resealed was originally under loan, the loan is extended for a one-year period. If the corn was originally under purchase agreement, a loan is initiated for the reseal period. The corn may be resealed in the same crib where it was stored the first year, or it may be shelled and placed in a farm bin for resealing. The county ASC offices supervise the entire reseal program.

The corn is inspected by a representative of the county ASC office at the time of resealing. If the corn grades No. 3 or better it is eligible for resealing. Records of the numerical grade and the grade factors of moisture content and test weight per bushel are maintained in the county offices. In some cases records of foreign material and total damage are also maintained. The quantity of corn is generally determined by the dimensions of the storage structure and the depth of the corn in the structure as established by the "corn sealer," a representative of the county office. The quantity is seldom determined by weight at the time of resealing.

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[2] Results of the study of elevator and bin site will be published in a separate report.

[3] Prior to April 1, 1954, the annual storage payment on 1952 reseal corn was 13 cents a bushel. Following that date it was 15 cents a bushel.

At the end of the reseal period, the method of determining the grade of the corn depends upon the disposition made. Farmers may deliver their resealed corn to CCC, or they may keep it themselves by redeeming the loan, or they may re-reseal it if an extended reseal program is authorized. In cases of delivery, the grade is established at the time and place of delivery. Such grade is established either by a country elevator, by a licensed inspector, or by a CCC-operated testing laboratory, depending upon where delivery is made. The quantity delivered is determined by weight.

In case the reseal loan is redeemed by the farmer, no grade is determined and recorded unless the farmer immediately markets the corn, in which case the grade is determined by the elevator buying it. If the corn is re-resealed the grade is determined by the county ASC office in the same manner as the original reseal grade.

POPULATION AND SAMPLE

Approximately 40 million bushels of 1952 price support corn were resealed on Iowa farms during 1953 and 1954. About 12 percent of this (4,761,281 bushels) was resealed by farmers in 10 counties used as the sample in an earlier study of bin site storage costs.[4] These 10 counties were selected as the reseal sample, primarily in the interest of economy. County offices were being visited to obtain records on corn stored at bin sites, and farm reseal records could be obtained during the same visits. This method of sampling also provided direct comparability of bin site information and farm reseal information, county by county. The counties had been selected randomly, 1 each from the 10 then-existing geographic ASC administrative districts in Iowa, so that the resulting stratification of the reseal sample is representative of various geographic areas of the State.

The population and sample of the farm reseal loans in each of the 10 sample counties are summarized in table 1. There were 3,385 reseal loans and 4,761,281 bushels of 1952 reseal corn in the 10 counties. A sub-sample of 284,080 bushels represented by 171 reseal loans was selected after reviewing summary information for all reseal loans in the 10 counties. The sub-sample includes approximately 5 percent of the reseal loans in the sample counties. Eighty-seven percent of the sample loans represented former loan corn and 13 percent former purchase agreement corn. This division is very similar to that for all corn in the price support program in Iowa.

Sample Size by Classification of Loans

The first column of table 2 identifies the 10 counties in which farm storage information was obtained. The next column shows the total number of farms in the sub-sample in each county. In the remaining columns the sample 1952 reseal loans are classified according to farm ownership, type of corn sealed, and original price support action.[5]

Seventy-three percent of the reseal loans in the sample had been obtained by owner-operators. Of the 171 farms in the sample, 55 percent had shelled corn storage and 45 percent had ear corn storage although these percentages varied considerably from county to county. As reported in table 1, almost 90 percent of the 171 farm reseal loans in the sample were originally placed under price support by commodity loan, and the remainder were originally under purchase agreement.

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[4] Costs of Storing Reserve Stocks of Corn in Country Elevators, at Bin Sites, and on Farms. U. S. Dept. Agr. Mktg. Res. Rpt. No 93, June 1955.

[5] The sample was not stratified by any of these 3 classifications; instead, it was randomly selected within each of the 10 counties.

Table 1.--Farm reseal loans of 1952 corn in ten sample counties in Iowa, according to type of original price support program

County Number	Total farm reseal loans						Sample					
	Original price support program				Total		Original price support program				Total	
	Purchase agreement		Reseal				Purchase agreement		Reseal			
	Number	Bushels	Number	Bushels	Number	Bushels	Number	Bushels	Number	Bushels	Number	Bushels
1	47	79,982	251	440,154	298	520,136	2	7,800	13	18,190	15	25,990
2	39	59,045	397	634,507	436	693,552	3	3,332	22	48,198	25	51,530
3	86	110,462	427	599,533	513	709,995	6	6,856	19	30,634	25	37,490
4	53	56,584	239	357,757	292	414,341	3	4,785	14	20,085	17	24,870
5	28	32,714	297	395,439	325	428,153	1	2,097	20	36,613	21	38,710
6	75	93,456	732	722,325	807	815,781	2	2,354	22	39,766	24	42,120
7	11	15,891	148	177,676	159	193,567	1	1,953	9	11,127	10	13,080
8	15	16,730	95	141,196	110	157,926	3	3,434	7	15,666	10	19,100
9	14	15,289	345	746,603	359	761,892	2	2,687	12	20,813	14	23,500
10	1	1,022	85	64,916	86	65,938	0	0	10	7,690	10	7,690
Total	369	481,175	3,016	4,280,106	3,385	4,761,281	23	35,298	148	248,782	171	284,080

Table 2.--Sample size and classification of farms storing 1952 loan corn in 1954, by county

County	Total farms	Farm ownership			Type of corn		In original price support program	
		Tenant	Land-lord	Owner-operator	Shelled corn	Ear corn	Reseal loan	Purchase agreement
Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
1	15	2	8	5	14	1	13	2
2	25	1	3	21	13	12	22	3
3	25	5	3	17	13	12	19	6
4	17	2	0	15	11	6	14	3
5	21	4	4	13	17	4	20	1
6	24	5	1	18	8	16	22	2
7	10	3	0	7	5	5	9	1
8	10	0	0	10	5	5	7	3
9	14	3	0	11	6	8	12	2
10	10	1	0	9	1	9	10	0
Total	171	26	19	126	93	78	148	23

METHOD OF OBTAINING INFORMATION

Records of corn resealed on Iowa farms are maintained in county ASC offices. Information for the study was obtained directly from county records late in 1954 and early in 1955 by representatives of the Iowa Agricultural Experiment Station. Summary information for all of the reseal loans in 10 sample counties was obtained as the basis for sub-sampling. At a later visit, detailed information on the 171 reseal loans in the sample was obtained from the files in these 10 county ASC offices.

Because the quantity of corn is determined by measure at the time of resealing, rather than by weight a total shrinkage figure could not be obtained for farm-resealed corn. Therefore, the volume of shrinkage due to moisture loss was computed by comparing the moisture content of the corn at the beginning of the reseal period with that at the end of the reseal period. This volume of shrinkage from moisture loss was converted to dollars at a uniform rate of $1.50 per bushel.

Market discounts used for loss in market value due to quality deterioration were based on those used over a comparable period by Commodity Credit Corporation in settlements with farm producers and warehousemen.

Discount for Damaged Kernels

On percent of damaged kernels the discounts used were as follows:

Percent damage		Cents per bushel discount
Over	Up to	
5	7	1
7	8	2
8	9	3
9	11	4
11	12	4.5
12	13	5
13	14	5.5
14	15	6
15	16	6.5
16	19	7
19	30	8

over 30 - additional 0.5 cents for each additional 1 percent damage

Foreign Material Discount

The foreign material discount used was 1 cent for each 1 percent foreign material over 3 percent. The discounts for special grade designation were (1) musty--1 cent except where mustiness occurs the total discount for all factors is not less than 2 cents; (2) weevily--2 cents; (3) sour--3 cents. Each of these factor discounts was used, where applicable, on both the grade factors at time of originally resealing the corn and at the time the reseal storage was terminated. The total net discount during the reseal period was computed from these individual discount figures.

Information obtained from the county ASC offices was checked and when possible supplemented with information obtained by personal interviews with the 171 farmers in the reseal sample at the time farm storage management schedules were taken. Information on the incoming and outgoing reseal grades for the farm storage sample was obtained primarily from records of the county ASC offices.

BUSHELS STORED AND STORAGE PERIOD

Total bushels stored and total storage period for the reseal loans in each county, as well as the average bushels stored and average storage period, are shown in table 3. The 171 farm storage units in the 10 counties stored an average of 1,661 bushels each. The average quantity stored varied from 769 bushels in county number 10 to 2,061 bushels in county number 2, but the other 8 counties stored quantities very close to the overall average of 1,661 bushels (column 6, table 3).

Table 3.--Total and average quantity stored and length of storage of 1952 corn reseal loans for the 10 sample counties in Iowa

1	2	3	4	5	6	7	8
County	Number of farms	Total			Average		
		Quantity stored	Length of storage	Bushel years of storage	Quantity stored	Length of storage	Bushel years of storage
		Bushels	*Months*	*Bushels*	*Bushels*	*Months*	*Bushels*
1	15	25,990	296	43,650	1,733	19.7	2,910
2	25	51,530	457	77,770	2,061	18.3	3,111
3	25	37,490	509	64,620	1,500	20.4	2,585
4	17	24,870	333	39,860	1,463	19.6	2,345
5	21	38,710	382	59,410	1,843	18.2	2,829
6	24	42,120	475	70,150	1,755	19.8	2,923
7	10	13,080	193	21,100	1,308	19.3	2,110
8	10	19,100	202	32,360	1,910	19.1	3,236
9	14	23,500	310	43,800	1,679	22.1	3,129
10	10	7,690	199	13,730	769	19.9	1,373
Total	171	284,080	3,356	466,380	1,661	19.6	2,727

Column 7 shows the average storage period for all 171 units was 19.6 months, and varied from 18.2 months in county number 5 to 22.1 months in county number 9.

The data for total bushel years of storage shown in column 5 are obtained by multiplying the total bushels stored by the average storage period in years. The total bushel years of storage for the 171 farm reseal loans was 466,380. The corresponding average bushel years of storage shown in column 8 is obtained by dividing the total bushel years of storage by the number of reseal loans involved. The overall average bushel years of storage was 2,727, and varied from 1,373 in county number 10 to 3,236 in county number 8.

The total and average storage volume and total and average length of storage by shelled and ear storage, by landlord, tenant and owner-operator ownership, and by reseal loans originally under loan and those originally under purchase agreement are shown in table 4. On the average, ear corn was stored about one month longer than shelled corn, but in smaller lots than the shelled corn (1,388 bushels as compared to 1,890 bushels).

Table 4.--Total and average storage volume, storage period, and bushel years of storage of 1952 corn reseal loans, by classification

Classification	Number of farms	Storage volume and storage period					
		Total			Average		
		Quantity stored	Period of storage	Bushel years of storage	Quantity stored	Period of storage	Bushel years of storage
		Bushels	*Months*	*Bushels*	*Bushels*	*Months*	*Bushels*
Ear...........	78	108,270	1,568	182,640	1,388	20.10	2,342
Shelled.......	93	175,810	1,788	283,740	1,890	19.23	3,051
Landlord......	19	43,590	375	71,500	2,294	19.74	3,763
Tenant........	26	41,090	516	68,220	1,580	19.85	2,624
Owner-operator	126	199,400	2,465	326,660	1,583	19.56	2,593
Reseal........	148	248,780	2,894	406,690	1,681	19.55	2,748
Purchase agreement...	23	35,300	462	59,690	1,535	20.09	2,595

There was little difference in the average storage period as between landlord, tenant and owner-operator reseal loans, but the quantity stored under the average reseal loan was substantially larger for landlord loans than for the other two groups (2,294 bushels compared to 1,580 and 1,582 bushels, respectively).

Relatively little difference existed in either the average loan size or the average storage period for reseal loans which were originally loan corn and those which were originally purchase agreement corn.

QUALITY DETERIORATION AND SHRINKAGE FROM MOISTURE LOSS

Extent of Loss During Reseal Period

The average loss in percentage moisture content during the reseal period was approximately three-fourths of 1 percent (0.76 percent) for the 171 reseal loans in the 10 counties. This average loss in moisture content ranged up to 2.22 percent for the 10 reseal loans in county number 10 as shown in column 3 of table 5. In two of the counties, numbers 5 and 7, the average moisture content actually increased during the reseal period.

The average number of bushels of shrinkage per reseal loan--from loss in moisture content--is shown for each of the counties in the fourth column of table 5. The overall average shrinkage was 13.78 bushels per reseal loan. The average shrinkage from moisture loss ranged from a negative shrinkage (or an increase) of 8 bushels in county number 5 to a shrinkage of 48 bushels per loan in county number 8.

Table 5.--Average shrinkage from moisture loss and average quality deterioration of 1952 corn stored on Iowa farms during reseal period, by county

County number	Reseal loans in sample	Shrinkage per loan due to moisture loss[1]			Discount per loan due to deterioration		Total value per loan of shrinkage and deterioration
					Per bushel	Total	
	Number	*Percent*	*Bushels*	*Dollars*	*Cents*	*Dollars*	*Dollars*
1	15	0.013	2.02	3.03	0	0	3.03
2	25	.152	16.62	24.93	.20	2.78	27.71
3	25	.776	12.46	18.70	.96	20.54	39.24
4	17	.70	7.97	11.90	.235	3.01	14.91
5	21	-.419	-8.14	-12.21	.10	1.31	-10.90
6	24	1.729	32.01	48.01	.042	.56	48.57
7	10	-.150	-1.30	-1.94	.40	4.00	2.06
8	10	2.06	47.96	71.93	.050	2.88	74.81
9	14	1.479	16.09	24.14	.050	1.51	25.65
10	10	2.22	17.52	26.27	.07	.14	26.41
Weighted average	171	.760	13.78	20.67	.246	4.48	25.15

[1] Value of stored corn set at $1.50 a bushel.

The average total dollar value of the shrinkage from loss in moisture content was obtained for each individual reseal loan by multiplying the bushel shrinkage by $1.50 per bushel. The figures shown in the fifth column of the table are the averages of dollar values of the shrinkage for the reseal loans in each county. The overall average value of shrinkage from moisture loss was $20.67 per reseal loan.

The average total per bushel discount due to quality deterioration is shown for the sample farms in each county in the sixth column of table 5. This discount averaged only a quarter of a cent (0.246 cent) per bushel for the 171 reseal loans during the reseal period. The county averages ranged from zero for the reseal loans in county number one to 0.96 cent per bushel for those in county number three. The average total dollar value of quality deterioration per reseal loan is shown in the next to last column. The overall average was $4.48; the county averages varied widely, ranging from zero in county number 1 to $20.54 in county number 3.

The last column of table 5 shows the average total effect of quality deterioration plus shrinkage from moisture loss on the market value of stored corn per reseal loan during the reseal period. This effect ranged from an average increase in value of $10.90 in county number 5 to a loss in market value of $74.81 per reseal loan in county number 8. The average total decrease in market value from these causes was $25.15 for the 171 loans.

Extent of loss per bushel, and per bushel year, of storage under reseal

The weighted average costs of quality deterioration and shrinkage from moisture loss per bushel, and per bushel year, for each of the 10 sample counties are shown in table 6. These weighted averages were obtained by dividing the total loss in market value for the sample farms in each county by the total bushels stored and the total bushel years of storage on these farms, respectively. The weighted averages for all 171 reseal loans in the 10 counties were obtained by the same process using the totals for all counties.

The loss in market value due to moisture loss averaged 1.24 cents per bushel stored, and .76 cent per bushel year of storage for the 171 farm reseal loans. Table 6 shows that the average losses from shrinkage were negative in counties number 5 and 7 where moisture losses for resealed corn during storage were more than offset by moisture gains.

Table 6.--Weighted average costs of shrinkage and quality deterioration per bushel and per bushel year of farm-stored corn, by county

County number	Cost of shrinkage[1]		Cost of quality deterioration		Cost of shrinkage plus quality deterioration	
	Per bushel stored	Per bushel year of storage	Per bushel stored	Per bushel year of storage	Per bushel stored	Per bushel year of storage
	Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
1	0.175	0.10	0	0	0.17	0.104
2	1.21	0.80	0.135	0.09	1.34	0.89
3	1.25	0.72	1.37	0.79	2.62	[2] 1.52
4	0.81	0.51	0.205	0.13	1.02	0.64
5	-0.66	-0.43	0.07	0.05	-0.59	[2] -0.39
6	2.74	1.64	0.03	0.02	2.77	1.66
7	-0.15	-0.09	0.31	0.19	0.16	0.10
8	3.77	2.22	0.15	0.09	3.92	2.31
9	1.44	0.77	0.09	0.05	1.53	0.82
10	3.42	1.91	0.02	0.01	3.44	1.92
Total	1.24	0.76	0.27	0.16	1.51	0.92

[1] Value of stored corn set at $1.50 a bushel.
[2] Discrepancies in totals are due to rounding.

The loss in market value due to quality deterioration while the corn was in storage, per bushel and per bushel year of storage, is shown in table 6. The overall average cost of quality deterioration was 0.27 cent per bushel, and 0.16 cent per bushel year, of storage. These figures ranged from zero in county number 1 to 1.37 cents and 0.79 cents, respectively, in county number 3.

The last two columns in the table show the weighted average total loss in market value from quality deterioration plus shrinkage, per bushel and per bushel year of storage, for each of the 10 counties. The overall weighted average was 1.51 cents per bushel, or 0.92 cent per bushel year of storage. These figures ranged from -.59 cent and -.39 cent (an appreciation in value) in county number 5, to 3.92 cents and 2.31 cents in county number 8.

RESEAL LOAN COSTS CLASSIFIED BY OWNERSHIP, TYPE OF CORN STORED, AND ORIGINAL PRICE SUPPORT PROGRAM

Total Costs

Total costs of quality deterioration and shrinkage from moisture loss are arranged by type of storage, by type of ownership, and by type of original price support action. Table 7 shows that the total cost of both quality deterioration and shrinkage was higher for the 78 reseal loans stored as ear corn than for the 93 as shelled corn. Also, the total cost of shrinkage was slightly higher for the 19 landlord reseal loans than for the 26 tenant reseal loans, but the total cost of quality deterioration was substantially higher for the tenant loans. The total cost of both shrinkage and quality deterioration for the 126 owner-operator reseal loans was higher than for those of the other two, but the cost per loan was less for this group. The 23 reseal loans originally price supported by purchase agreements had a sufficient increase in total market value due to an increase in moisture content during storage to more than offset the total decrease due to quality deterioration.

Table 7.--Total costs of shrinkage and quality deterioration during reseal period of farm-stored corn, by classification

Classification	Number of farms	Total costs		
		Shrinkage	Quality deterioration	Shrinkage plus quality deterioration
		Dollars	*Dollars*	*Dollars*
Ear....................	78	2,304.31	427.13	2,731.44
Shelled................	93	1,230.63	339.54	1,570.17
Landlord...............	19	740.91	5.59	746.50
Tenant.................	26	735.88	109.32	845.20
Owner-operator.........	126	2,058.15	651.76	2,709.91
Reseal.................	148	3,718.10	589.04	4,307.14
Purchase agreement......	23	-183.16	177.63	-5.53

Average costs

From the average per unit loss in market value due both to shrinkage from moisture change and to quality deterioration shown in table 8, it is concluded that:

(1) Losses from both causes are substantially higher in ear corn storage than in shelled corn storage. This is true on the basis of bushels stored and also on the basis of bushel years of storage.

(2) The per unit loss in market value due to shrinkage from moisture loss averaged lowest for the owner-operator storage, but the cost of quality deterioration was highest for this group. The combined cost of shrinkage and quality deterioration was substantially lower for the owner-operator group than for either landlords or tenants. It was highest for the tenants.

(3) The per unit cost of quality deterioration averaged somewhat less for the reseal group than for the purchase agreement group. However, for the purchase agreement group there was a gain in market value due to change in moisture content. This resulted in a small net per unit increase in market value for the former purchase agreement corn while it was resealed in farm storage bins.

RELATION OF COSTS OF QUALITY DETERIORATION AND SHRINKAGE PER BUSHEL YEAR OF STORAGE TO MANAGEMENT INDEX, BUSHELS STORED, AND LENGTH OF STORAGE

Several assumptions were made prior to obtaining records on physical changes in stored corn and costs associated with such changes. It was expected that costs of shrinkage from change in moisture content and of deterioration in quality per bushel year of storage would be dependent, at least in part, on the management[6] of the corn in storage, the size of the storage unit, and the number of months the corn was in storage. In general, it was expected that costs per bushel would be lower if approved storage management practices were used; would be greater if storage units were large, because of moisture migration and other problems encountered with larger storage units; and would increase as the period of storage was extended.

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[6] An index of storage management was compiled as a means of determining the degree to which several generally approved storage management practices have been accepted. The areas studied and values assigned to their importance are subjective but reasons for their selection are explained in Appendix A.

Table 8.--Average cost of shrinkage and quality deterioration per bushel and per bushel year of storage of farm-stored corn, by classification

Classification	Cost of shrinkage		Cost of quality deterioration		Cost of shrinkage plus quality deterioration	
	Per bushel stored	Per bushel year of storage	Per bushel stored	Per bushel year of storage	Per bushel stored	Per bushel year of storage
	Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
Ear.............	2.13	1.26	0.39	0.23	2.52	1.49
Shelled.........	0.70	0.43	0.19	0.12	0.89	0.55
Landlord........	1.70	1.04	0.01	0.01	[1] 1.70	[1] 1.04
Tenant..........	1.79	1.08	0.27	0.16	2.06	1.24
Owner-operator..	1.03	0.63	0.33	0.20	1.36	0.83
Reseal..........	1.49	0.91	0.24	0.14	1.73	[1] 1.06
Purchase agreement.....	-0.52	-0.31	0.50	0.30	-0.02	-0.01

[1] Discrepancies in totals are due to rounding.

After data from storage records were compiled, considerable variation was observed among the 171 sample farm reseal loans of 1952 corn with respect to the size of the storage unit, the length of storage, and the degree of storage management, as well as in the observed costs of quality deterioration and shrinkage. To obtain a more precise measure of the relationship between the observed costs and the three factors which were assumed to affect these costs, multiple regression analysis was employed to examine the data obtained for the sample reseal loans.

The multiple regression equations[7] explained only about 5 percent of the total variation in the observed costs of quality deterioration and shrinkage, but the results approached statistical significance at the 0.05 probability level.

On the basis of the regression equation for all 171 reseal loans, the costs of both shrinkage from moisture change and shrinkage plus quality deterioration, per bushel year of storage, were found to decrease as the management index score increased, as one would expect. Also, losses from shrinkage and deterioration were found to increase with increases in the number of months stored and the bushels stored, as expected. The unit cost of shrinkage from moisture loss plus quality deterioration per bushel year of storage

(a) decreased by one-hundredth of a cent with each increase of 5 points in the management index;

(b) increased about one-tenth of a cent with each month's increase in the length of storage; and

(c) increased by one-hundredth of a cent with each 83-bushel increase in the bushels stored.[8]

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[7] See Appendix B.

[8] The estimated cost of shrinkage plus quality deterioration in cents per bushel year is determined by adding 0.108 times the months of storage to 0.00012 times the bushels stored and subtracting from this sum of 0.002 times the management index and 1.08.

Considering only the cost of shrinkage per bushel year of storage, costs

(a) decreased by one-hundredth of a cent with each 4.76 point increase in the management index;

(b) increased by one-tenth of a cent with each 1.03 month's increase in the storage period; and

(c) increased by one-hundredth of a cent with each 91-bushel increase in the bushels of corn stored.[9]

RESEAL LOANS FOR SHELLED CORN

Similar linear multiple regression equations were fitted to the data separately for the shelled corn reseal loans and the ear corn reseal loans. The equations for the shelled corn storage explained between 6 and 9 percent of the variation in the observed loss in market value, and the multiple correlation coefficients were significant (or nearly so) at the 0.05 probability level.

For the shelled corn storage, the cost of shrinkage plus quality deterioration per bushel year

(a) decreased by one-hundredth of a cent with each 11 points increase in the management index;

(b) increased by about one-tenth of a cent with each 0.9 of a month's increase in the length of storage; and

(c) increased by one-hundredth of a cent with each 40 bushels increase in the bushels stored.[10]

In the case of the shelled corn storage equation, coefficients for costs of shrinkage followed a pattern similar to those for the two costs combined.

RESEAL LOANS FOR EAR CORN

The equation for ear corn storage explained less than 1 percent of the observed loss in market value, and the multiple coefficient correlations were not statistically significant. Not only were the relationships between the independent variables and the per unit loss in market value for ear corn statistically non-significant, but also they were substantially different from those for shelled corn storage and for all reseal loans taken together.

In the case of ear corn storage; the following findings were developed:

(a) A slight positive relationship existed between the loss in market value and the management index. Evidently either the index of management obtained did not adequately measure good management practices for ear corn, or else good storage management of ear corn was not associated with decreases in the loss of market value during storage.[11]

(b) An unexpected negative relationship was found between the length of storage and the loss of market value per bushel year of storage for the ear corn storage.

(c) A positive relationship was found between the bushels stored and the loss in market value per bushel year. This is the only finding in regard to ear corn reseal loans which seems reasonable.

The total regression equations for ear corn storage did not explain a significant part of the total variation in the loss in market value of reseal corn stored in the ear. The relationships found consequently cannot be considered dependable.

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[9] This equation was $Y_2 = -1.03 -.0021X_1 + 0.098X_2 + 0.00011X_3$ (see the Statistical Appendix).

[10] The estimated cost of shrinkage plus quality deterioration in cents per bushel year is determined by adding .114 times the month of storage to 0.00025 times the bushels stored and subtracting from this sum of 0.0009 times the management index and 2.07.

[11] Further research is needed to develop a more precise measure of storage management than the indices used in this study.

APPENDIX A

Management Index

An index was prepared as an experiment in quantitative analysis of storage management practices. This index is a device to determine the degree to which management practices vary among farms, the practices most commonly used in storage management, and the relationship such management practices have to costs incurred in losses from shrink and quality deterioration. The authors recognize that this approach is subjective and that further study is needed before a conclusive index can be obtained. The management index compiled for each reseal loan measured 5 different types of storage management information. Except for one item the information used in the index was identical for both ear corn storage and shelled corn storage. The areas of storage management used in preparing the index were:

1. Preparation and filling

   a. Shelled corn--removal of screenings during shelling and bin filling.
      Affirmative answers to the question, "Were sweepings from the crib floor or the screenings under the sheller run through the sheller and into the bin?" were scored zero, and negative answers were scored 10.

   b. Ear corn--crib preparation and repairs
      Affirmative responses to the question as to whether the crib had been cleaned out and repaired prior to filling were scored 10, and negative responses to the question were scored zero.

2. Use of a residual insecticide

   A "yes" answer to the question "Was structure sprayed with a residual insecticide before putting in corn?" was scored 10, and a "no" answer was scored zero. No attempt was made to refine the score on the basis of the brand or type of insecticide used, nor on the method or quantity of application.

3. Inspections made

   Respondents were asked to describe the method and frequency of visual inspection of the structure during the reseal period. Replies were scored on the basis of 10 points for each adequate inspection per year.

4. Rodent control

   Respondents were asked to describe the methods of rodent control employed. Ten points were given for each major method of rodent control. Where bait was used periodically, such as in the fall and in the spring, 10 points were allowed for each time the bait was used.

5. Fumigation

   Respondents were asked whether or not the corn was fumigated, and if so, the number of times and detailed information about each fumigation. Ten points were given for each fumigation. No attempt was made to refine the score on the basis of the fumigant used or the method of application.

A total management index was obtained by adding the scores in each of the five areas. The average scores for the reseal loans in each of the 10 counties are shown in table 9.

The preparation and filling score averaged 6.6 for the 171 reseal loans, and ranged from an average of 4.3 in county number 9 to 8.7 in county number 1. The residual insecticide score averaged 1.6 for the 171 reseal loans. Since these 2 areas were scored zero or 10, the scores also indicate the percent of the sample farms that followed each of these practices. For example, 66 percent of the 171 farms answered in the affirmative on the question concerning preparation and filling of the bin, while only 16 percent indicated that a residual insecticide was used.

Table 9.--Average management practices score and total management index of resealed corn on sample Iowa farms by county

County number	Number of farms	Shelled- were screenings removed? Ear- was crib cleaned out and repaired? Yes-10; No-0	Residual insecticide used? Yes- 10; No- 0	Inspections made (number per year X 10)	Rodent control (number of times X 10)	Fumigation (number of times X 10)	Total management index
1	15	8.7	2.0	6.5	6.0	0.7	23.8
2	25	5.2	0.4	3.6	2.4	0	11.6
3	25	7.2	1.6	5.3	3.6	1.6	19.3
4	17	6.0	2.3	3.0	3.5	0.6	15.3
5	21	8.1	1.9	7.3	3.3	1.9	22.5
6	24	7.5	1.2	4.0	6.7	0	19.4
7	10	7.0	0	2.6	5.0	1.0	15.6
8	10	6.0	3.0	4.9	3.0	1.0	17.9
9	14	4.3	2.1	4.0	4.3	1.4	16.1
10	10	5.0	2.0	5.4	5.0	0	17.4
Weighted average all counties		6.6	1.6	4.6	4.3	0.8	17.9

The number of adequate visual inspections averaged 4.6 per year for the entire sample, as is shown in the fifth column of table 9. The highest average score in this area was 7.3 for county number 5 and only 2.6 in county number 7. The rodent control score averaged 4.3 for the entire sample, and varied from an average of 2.4 in county number 2 to an average of 6.7 in county number 6. Fumigation was most rarely used of all of the 5 storage management practices going into the management index. It averaged only 0.8 for the 171 reseal loans, and averaged zero in counties number 2, 6, and 10. The county with the highest average in this area was county number 5, with an average score of 1.9.

The average total storage management index is shown in the last column of table 9. This index averaged 17.9 for the 171 farm storage units, ranging from an average of 23.8 in county number 1 to an average of 11.6 in county number 2.

The average management index by type of storage, by type of ownership, and by type of original price support action is shown in the tenth column of table 10. The findings indicate that:

(1) The index averaged almost twice as high for the reseal loans stored as shelled corn as it did for those stored as ear corn. This difference indicates that considerably more managerial attention was given to storage for shelled corn than for ear corn.

(2) The management index average was almost identical for storage by tenants and by owner-operators. The index averaged somewhat higher for storage by the landlords, indicating that this group gave greater attention to accepted management practices.

(3) A higher managerial score is reported for reseal loans on corn that originally received price support by purchase agreement than for the reseal corn originally price supported by loans.

Table 10.--Management index of farm-stored corn, by classification

Classification	Number of farms	Management index	
		Total	Average
Ear....................	78	959	12.29
Shelled..............	93	2,090	22.47
Landlord..............	19	402	21.16
Tenant................	26	444	17.08
Owner-operator........	126	2,203	17.48
Reseal................	148	2,579	17.43
Purchase agreement....	23	470	20.43

APPENDIX B

Statistical Analysis

The farm storage data were examined statistically to measure the relationships of the loss in market value of corn during storage to the management index, the storage, period, and the size of the storage unit. The following linear multiple regression models were used.

(1) $Y_1 = b_o + b_1 X_1 + b_2 X_2 + b_3 X_3$

(2) $Y_2 = b_o + B_1 X_1 + b_2 X_2 + b_3 X_3$, where

Y_1 = cost of moisture shrinkage plus quality deterioration per bushel year of storage coded by multiplying by 100 and adding 500.[12]

Y_2 = cost of moisture shrinkage per bushel of storage, coded by multiplying by 100 and adding 500.

X_1 = management index.

X_2 = months of storage, coded by multiplying by 10.

X_3 = bushels stored, coded by dividing by 10.

Using these equations as models the B parameters in the several multiple regression equations were estimated by the method of least squares from the farm storage data obtained from the sample. The data used were

For Y_1, column 7, tables 3-1 through F-3-10
For Y_2, column 3, tables 3-1 through F-3-10
For X_1, column 8, tables 2-1 through F-2-10
For X_2, column 6, tables 2-1 through F-2-10
For X_3, column 5, tables 2-1 through F-2-10

Both Y_1 and Y_2 regression equations were determined for (1) all 171 farm storage units, (2) the 93 units storing as shelled corn, and (3) the 78 units storing as ear corn. In addition exploratory Y_1 regression equations were determined for each of the separate cells containing a sufficient number of observations to warrant it. Examples of such cells include, (1) owner-operator, shelled corn, loan, (2) landlord, shelled corn, loan, (3) owner-operator, ear corn, loan, etc. None of these regression equations by individual cells resulted in a significant multiple correlation coefficient.

The resulting regression equations for the 171 farm storage units were

(3) $Y_1 = 392.06 - .20X_1 + 1.08X_2 + .12X_3;\ R^2 = .041$

(4) $Y_2 = 397.25 - .21X_1 + .98X_2 + .11X_3;\ R^2 = .044$

The multiple correlation coefficients (R's) were .20 for equation (3) and .209 for equation (4). An R of .215 is significant at the .05 probability level in this case.[13]

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[12] The coding was done to avoid negative numbers, and to make the value of and magnitude of variation in the several variables more comparable.

[13] Snedecor, G. W., Statistical Methods. Ed. 4, p. 351. Iowa State College Press, Ames, 1946.

The standard errors for the partial regression coefficients are as follows:

For equation (3)

$b_1 = -.20$ $sb_1 = .11$
$b_2 = 1.08$ $sb_2 = .57$
$b_3 = .12$ $sb_3 = .115$

For equation (4)

$b_1 = -.21*$ $sb_1 = .10$
$b_2 = .98$ $sb_2 = .53$
$b_3 = .11$ $sb_3 = .11$

Although several of the other partial regression coefficients are nearly so, only b_1 in equation (4) is significant at the .05 proability level.[14]

The simple correlation coefficients (r's) among the variables in equations (3) and (4) are shown in the table below:

	X_1	X_2	X_3	Y_1	Y_2
X_1	1	.03	.206	-.12	-.13
X_2		1	-.006	.14	.13
X_3			1	.05	.05
Y_1				1	xxx
Y_2					1

The multiple regression equations for the 93 shelled corn farm storage units were

$$(5)\ Y_1 = 293.32 - .09X_1 + 1.14X_2 + .25X_3;\ R^2 = .065$$

$$(6)\ Y_2 = 294.36 - .07X_1 + .97X_2 + .32X_3;\ R^2 = .086$$

The multiple correlation coefficients (R's) were .255 for equation (5) and .294 for equation (6). In this case an R of .29 is significant at the .05 probability level.

The standard errors for the partial regression coefficients are:

For equation (5)

$b_1 = .09$ $sb_1 = .144$
$b_2 = 1.14$ $sb_2 = .631$
$b_3 = .25$ $sb_3 = .156$

For equation (6)

$b_1 = .07$ $sb_1 = .129$
$b_2 = .97$ $sb_2 = .586$
$b_3 = .32*$ $sb_3 = .140$

Although several of the other partial regression coefficients are nearly so, only b_3 in equation (6) is significant at the .05 probability level.[15]

The multiple regression equations for the 78 ear corn farm storage units were

$$(7)\ Y_1 = 743.52 + .05X_1 - .60X_2 + .10X_3;\ R^2 = .008$$

$$(8)\ Y_2 = 759.13 + .008X_1 - .67X_2 + .03X_3;\ R^2 = .007$$

The multiple correlation coefficients (R's) were .088 for equation (7) and .0819 for equation (8). Neither is significant.

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[14] The "t" test with 167 degrees of freedom. Ibid., p. 65.

[15] The "t" test with 89 degrees of freedom. Ibid., p. 65.

Multiple regression equations (3), (4), (5) and (6) are based on the coded variables as explained above. However, these equations can be quickly converted so as to apply to the variables when they are not coded. This can be illustrated for equation (3), step by step.

1. 500 was added to the cost of shrinkage plus deterioration this amount can be subtracted from both sides of the equation,

$$Y_1 - 500 = 392.06 - 500 - .20X_1 + 1.08X_2 + .12X_3$$

$$Y_{11} = -107.94 - .20X_1 + 1.08X_2 + .12X_3$$

2. The cost of shrinkage plus deterioration was also multiplied by 100; the equation can be divided by 100,

$$\frac{Y_{11}}{100} = \frac{-107.94}{100} - \frac{.20X_1}{100} + \frac{1.08X_2}{100} + \frac{.12X_3}{100}$$

$$Y_{12} = 1.0794 - .002X_1 + .0108X_2 + .0012X_3$$

3. Y_{12} = storage cost in cents per bushel per year.

X_1 = the management index (this variable was not coded).

X_2 = months of storage multiplied by ten; if months storage is designated by X_{23}, then $X_{23} = 10 X_2$.

X_3 = bushels stored divided by ten; if bushels stored is designated by X_{33}, then $X_{33} = \frac{X_3}{10}$

Substituting: $Y_{12} = 1.0794 - .002X_1 + .108X_{23} + .00012X_{33}$

Equations (4), (5) and (6) can be restated so as to apply to the variables without coding.